AD-A266 476

LABORATORY NOTE NO. 83

TRAUMATIC BRAIN INJURY GENERATES BIPHASIC HEMODYNAMIC RESPONSES IN THE SWINE

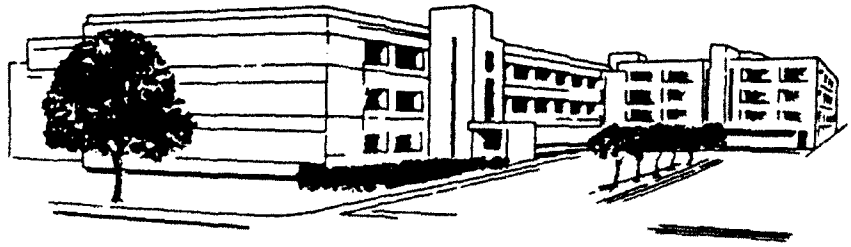
The Dac Tran
Gregory Hanson
Juergen W. Pfeiffer
Michael A. Dubick
X.Q. Yuan

Division of Military Trauma Research

DTIC
ELECTE
JUL 06 1993
S E D

April 1993

93-15207



LETTERMAN ARMY INSTITUTE OF RESEARCH PRESIDIO OF SAN FRANCISCO CALIFORNIA 94129

STATEMENT A
Approved for public release;
Distribution Unlimited

Traumatic Brain Injury Generates Biphasic Hemodynamic Responses in the Swine—The Dac Tran, et al

This document has been approved for public release and sale; its distribution is unlimited.

Destroy this report when it is no longer needed. Do not return to the originator.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

The experimental studies of the author described in this report were reviewed and approved by the Institutional Review Committee/Animal Care and Use Committee at Letterman Army Institute of Research. The manuscript was peer-reviewed for compliance prior to submission for publication. In conducting the research described here, the author adhered to the "Guide for the Care and Use of Laboratory Animals,"DHHS Publication (NIH) 86-23.

This material has been reviewed by Letterman Army Institute of Research and there is no objection to its presentation and/or publication. The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official nor as reflecting the views of the Department of the Army or the Department of Defense. (*AR 360-5*)

John R. Hess 3 May 93
(date)
COL, MC
Commander

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT This document has been approved for public release, distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Laboratory Note No. 83	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Division of Military Trauma Research 6b. OFFICE SYMBOL (If applicable) SGRD-ULT-M	7a. NAME OF MONITORING ORGANIZATION U. S. Army Research and Development Command
6c. ADDRESS (City, State, and ZIP Code) Letterman Army Institute of Research Presidio of San Francisco, CA 94129-6800	7b. ADDRESS (City, State, and ZIP Code) Fort Detrick Frederick, MD 21701-5012
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 61102A; PROJECT NO. BS14; TASK NO S14/CC; WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
Traumatic Brain Injury Generates Biphasic Hemodynamic Responses in the Swine

12. PERSONAL AUTHOR(S)
The Dac Tran, Gregory Hanson, Juergen W. Pfeiffer, Michael A. Dubick, and X.-Q. Yuan

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Laboratory Note	FROM 7/91 TO 7/92	April 1993	10

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	
			Brain trauma, hemodynamics

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The cardiovascular performances of 10 male Yorkshire swine were investigated following moderate to severe brain trauma that was induced by a fluid percussion device. Arterial pressure, cardiac output, heart rate, and pulmonary arterial pressure reached their highest values 20 seconds after brain trauma. Except for the heart rate, these cardiovascular variables dropped below their baseline values 2 hours after the trauma. These data indicate that brain trauma may significantly suppress cardiovascular performance.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
[X] UNCLASSIFIED/UNLIMITED [ ] SAME AS RPT. [ ] DTIC USERS	UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
John R. Hess, COL, MC, Commanding	(415)561-3600	SGRD-ULT

ABSTRACT

The cardiovascular performances of 10 male Yorkshire swine were investigated following moderate to severe brain trauma that was induced by a fluid percussion device. Arterial pressure, cardiac output, heart rate, and pulmonary arterial pressure reached their highest values 20 seconds after brain trauma. Except for the heart rate, these cardiovascular variables dropped below their baseline values 2 hours after the trauma. These data indicate that brain trauma may significantly suppress cardiovascular performance.

PREFACE

The study reported here was accomplished during The Dac Tran's tenure in the Division of Military Trauma Research as a Summer Student Fellow of the American Heart Association, California Affiliate.

Accesion For	
NTIS CRA&I	X
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

DTIC QUALITY INSPECTED 3

Traumatic Brain Injury Generates Biphasic Hemodynamic Responses in The Swine- TD Tran, G Hanson, JW Pfeiffer, MA Dubick, X-Q Yuan

According to one estimate, each year almost 1 million people in the United States suffer from head injuries and more than 400,000 of these are admitted to hospitals [1]. There are about 100,000 deaths of traumatic head injuries each year, many of them die before reaching a hospital [1]. In conventional war, trauma to the central nervous system causes about one-third of all deaths [2]. Among Vietnam combat casualties, head trauma was the most common cause of hospital deaths (42%) [3]. Another study showed that the incidence of head injuries increased markedly from 17% in the Korean conflict to 30% in the 1973 Middle East war [4].

Previous studies showed that in a rat model, head trauma not only suppressed the spontaneous hemodynamic recovery from hemorrhage, but also suppressed the efficacy of fluid resuscitation [5,6]. However, the exclusive effects of traumatic brain injury on cardiovascular function in non-hemorrhaged animals have not been precisely examined. In the present study, we used a swine model to characterize the hemodynamic responses to brain trauma.

MATERIALS AND METHODS

Male Yorkshire swine (25-35 Kg) were fasted overnight. Anesthesia was induced in each animal through a mask by isoflurane and maintained by a balanced anesthesia, which consisted of an intramuscular injection of Innovar-vet (0.11 ml/kg), inhalation of isoflurane (0.5%) and nitrous oxide (50%), and intravenous infusion of fentanyl (0.6 ug/kg/min) and succinylcholine (0.2 mg/kg/min). Polyethylene catheters were placed in the femoral arteries to monitor blood pressure, and to collect blood samples. A Swan-Ganz catheter (7.5 F, American Edward Labs, Irvine, CA) was inserted into the pulmonary artery through the left femoral vein to determine central venous, pulmonary arterial and wedge

pressures, and to inject the cold saline to measure cardiac output by the thermodilution method using an American Edwards Cardiac Output computer. All catheters were attached to pressure transducers (Gould) which were connected to a Gould ES-2000 multi-channel monitor and recorder for continuous monitoring and recording of the pressures and electrocardiogram. After completing the instrumentation, at least one hour was allowed for hemodynamic stabilization. Cardiovascular variables listed above were measured before head trauma and at intervals over a 2 hr period after injury. In addition, systemic vascular resistance was calculated by subtracting central venous pressure from mean arterial pressure and dividing by the cardiac output. The results were expressed as resistance units (RU). Cardiac index was calculated by dividing cardiac output by body weight and the results expressed as L/min/kg. During the experiment, mechanical ventilation was maintained, and only an intravenous infusion of fentanyl (0.2 ug/kg/min) and succinylcholine (0.07 ug/kg/min) was continued [7].

A fluid percussion brain trauma model was used in this study. Fluid percussion brain injury models have been used in many species, including dog, cat and rat [8-11]. This type of model was produced with a fluid percussion device to simulate a closed head injury that often occurs in a motor vehicle accident or battlefield casualty. The main part of the trauma device is a 60 cm long Plexiglas cylinder filled with isotonic saline. The injury is induced by a metal pendulum, which strikes the piston at one end of the cylinder from a predetermined height. The resulting impulse is measured extracranially at the time of strike via the transducer mounted at the other end of the cylinder and recorded on a storage oscilloscope. The oscilloscope is triggered photoelectrically by the descent of the pendulum. The impulse generated is transmitted through the fluid in the cylinder into the cranial cavity of the animal. The impact level we implemented ranged from 4.09 to 5.79 atmospheres.

RESULTS

All data are expressed in mean ± standard error of mean.

Mean Arterial Pressure (mmHg) (Fig 1A)

After the brain had been injured, the mean arterial pressure increased from the baseline value of 123 ± 4 mmHg to 179 ± 7 mmHg at 10 seconds, and it continued to increase to 186 ± 7 mmHg at 20 seconds. At 2 hours after trauma the mean arterial pressure began to decrease to 102 ± 11 mmHg.

Heart rate (beats/min) (Fig 1B)

The heart rate increased from 112 ± 7 beats per minute at the baseline to 190 ± 15 beats per minute 10 seconds after the injury. It continued to increase to 224 ± 16 beats per minute at 20 seconds after the injury. The heart rate then decreased, but at 2 hours after brain trauma, the heart rate was 152 ± 20 beats per minute, which remained higher than the baseline value.

Cardiac output (L/min) (Fig 2A)

The cardiac output increased from 6.1 ± 0.7 L/min at the baseline to 7.7 ± 0.8 L/min at 1 minute after the brain trauma, then decreased to 5.5 ± 0.4 L/min at 2 hours after the trauma. Cardiac index followed a trend similar to that observed for cardiac output (Fig 2B).

Mean pulmonary arterial pressure (mmHg) (Fig 3A)

The mean pulmonary arterial pressure increased from a baseline of 15.6 ± 1.3 mmHg to 26.4 ± 3.3 mmHg at 10 seconds after the trauma. At 20 seconds after trauma, it increased to 28.7 ± 4.0 mmHg, and then rapidly declined to 13.3 ± 0.9 at 15 min after the injury. At 2 hours after the trauma mean pulmonary arterial pressure was 13.1 ± 1.7 mmHg.

Systemic vascular resistance (RU) (Fig 3B)

Systemic vascular resistance rose about 10% 1 min after head trauma, fell below baseline at 9 min, and slowly rose toward baseline levels over the 2 hr experimental period.

DISCUSSION

Our data showed that mechanical brain injury induced rapid increases in arterial pressure, cardiac output, heart rate, and pulmonary arterial pressure. This immediate hyperdynamic response may be caused by a sympathoadrenal activation [5,11]. Despite the apparent elevated sympathoadrenal activity indicated by persistent tachycardia, a hypodynamic profile ensued as indicated by prompt decreases in arterial pressure and cardiac output. By 20 min after the injury, arterial pressure dropped below baseline. A substantial decline in cardiac output without a simultaneous significant change in systemic vascular resistance suggests that the cardiac function may have been damaged following severe brain injury [12-15]. It is important to keep this in mind when resuscitating a multiple trauma patient with head injury or managing a donor heart from a traffic accident victim.

More studies are needed to define the effects of head trauma on cardiac contractility and other functions and to examine therapeutic means to avoid or reduce head trauma-induced heart dysfunction.

CONCLUSION

Severe traumatic brain injury creates an immediate hyperdynamic response followed by a hypodynamic state, which may be caused by a compromised cardiac function.

REFERENCES

1. U.S. Department of Health and Human Services. Head Injury. NIH publication No. 84-2478; August 1984.

2. Bellamy RF. The Cause of Death in conventional land warfare : Implications for combat casualty care research. Mil Med 149:55-62, 1984.

3. Arnold K, Cutting RT: Causes of death in United States military personnel hospitalized in Vietnam. Mil Med 143:161-164, 1978.

4. Barsoum RS, Rihan ZEB, Balig OK, Hozayen A, El-Ghoneimi EG, Ramzy MF, Ibrahuim AS: Acute renal failure in 1973 Middle East War--Experience of a specialized base hospital: Effect of the site of injury. J Trauma 20:303-307, 1980.

5. Yuan XQ, Wade CE, Clifford CB: Suppression by traumatic brain injury of spontaneous hemodynamic recovery from hemorrhagic shock in rats. J Neurosurg 75:408-414, 1991.

6. Yuan XQ and Wade CE: Traumatic brain injury attenuates the effectiveness of lactated Ringer's solution resuscitation of hemorrhagic shock in rats. Surg Gyn Obstet 174:305-312, 1992.

7. Hansen DE, Borow KM, Neumann A, Lang RM, Fujii AM, Schumaker PT, Wood LDH. Effects of acute lung injury and anesthesia on left ventricular mechanics. Am J Physiol 251:H1195-H1204, 1986.

8. Millen JE, Glauser FL, Fairman P: A comparison of physiological responses to percussive brain trauma in dogs and sheep. J Neurosurg 62: 587-591, 1985.

9. McIntosh TK, Head VA, Faden AI: Alterations in regional concentrations of endogenous opioids following traumatic brain injury in the cat. Brain Res 425:225-233, 1987.

10. Yuan XQ, Prough DS, Smith T, DeWitt DS: The effects of traumatic brain injury on regional cerebral blood flow in rats. J Neurotrauma 5(4):289-301, 1988.

11. Rosner MJ, Newsome HH, Becker DP: Mechanical brain injury: The sympathoadrenal response. J Neurosurg 61:76-86, 1984.

12. Cruickshank JM, Neil-Dwyer G, Hayes Y, et al: Stress/catecholamine-induced cardiac necrosis, Postgrad Med J Feb 29; Spec No:140-147, 1988.

13. Davis RA, Cunningham PS: Prognostic factors in severe head injury. Surg Gyn Obstet 159:597-604, 1984.

14. McLeod AA, Neil-Dwyer G, Meyer CHA, et al: Cardiac sequelae of acute head injury. Br Heart J 47:221-226, 1982

15. Pilati CF, Clark RS, Gilloteaux J, et al: Excessive sympathetic nervous system activity decreases myocardial contractility. Proc Soc Exp Biol Med 193:225-231, 1990

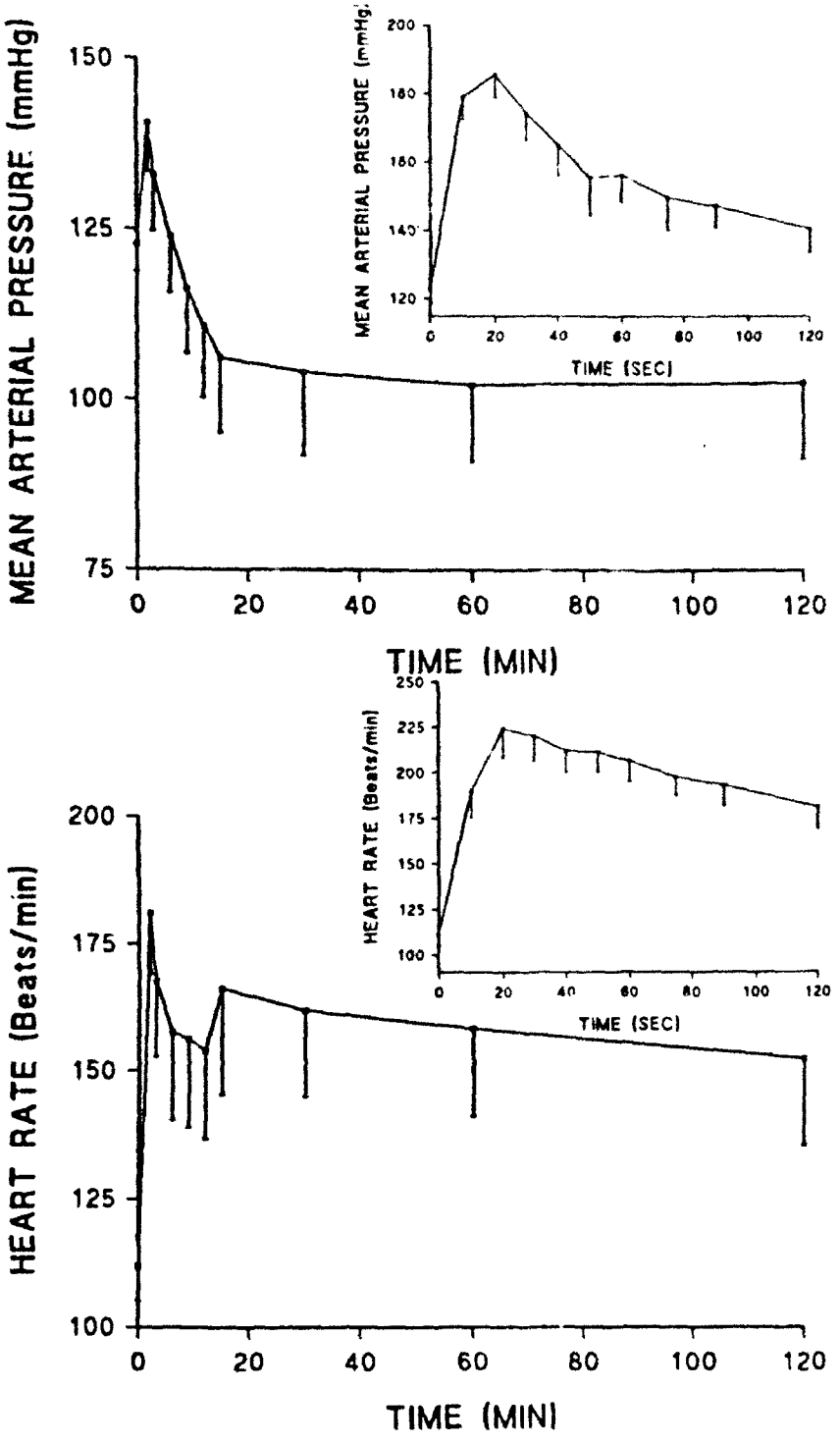
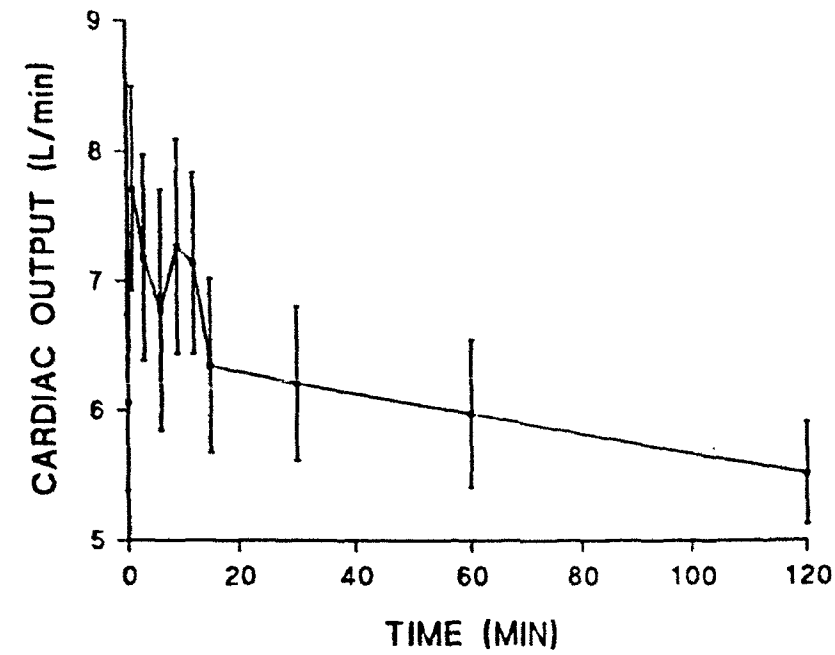


Fig. 1. (A) Mean arterial pressure and B) Heart Rate before and following head trauma. Data expressed as mean $\pm$ S.E. from 10 pigs. Small figures depict events over first 120 sec following head injury.



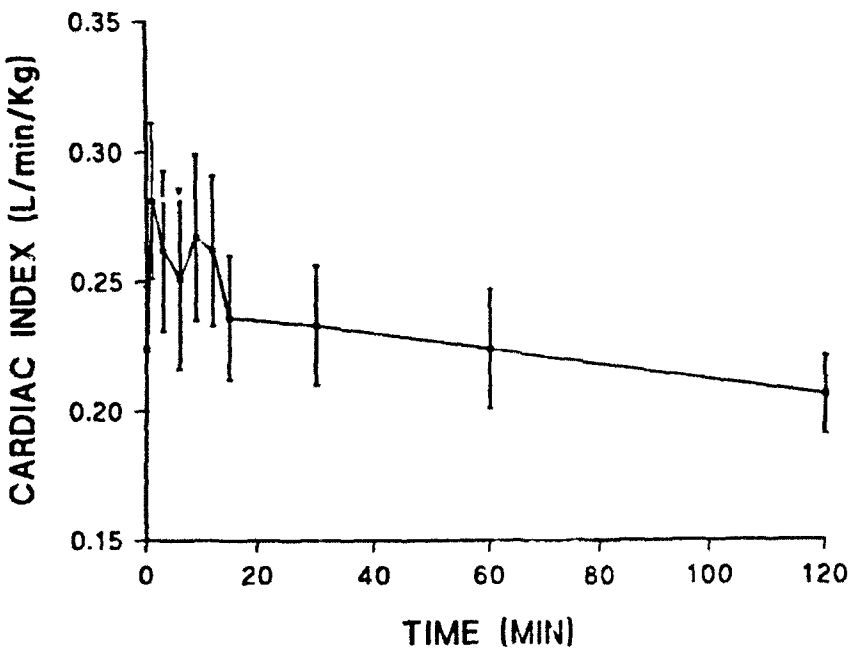


Fig. 2 A) Cardiac output and B) Cardiac Index before and following head trauma. Data expressed as mean ± S.E. from 10 pigs.

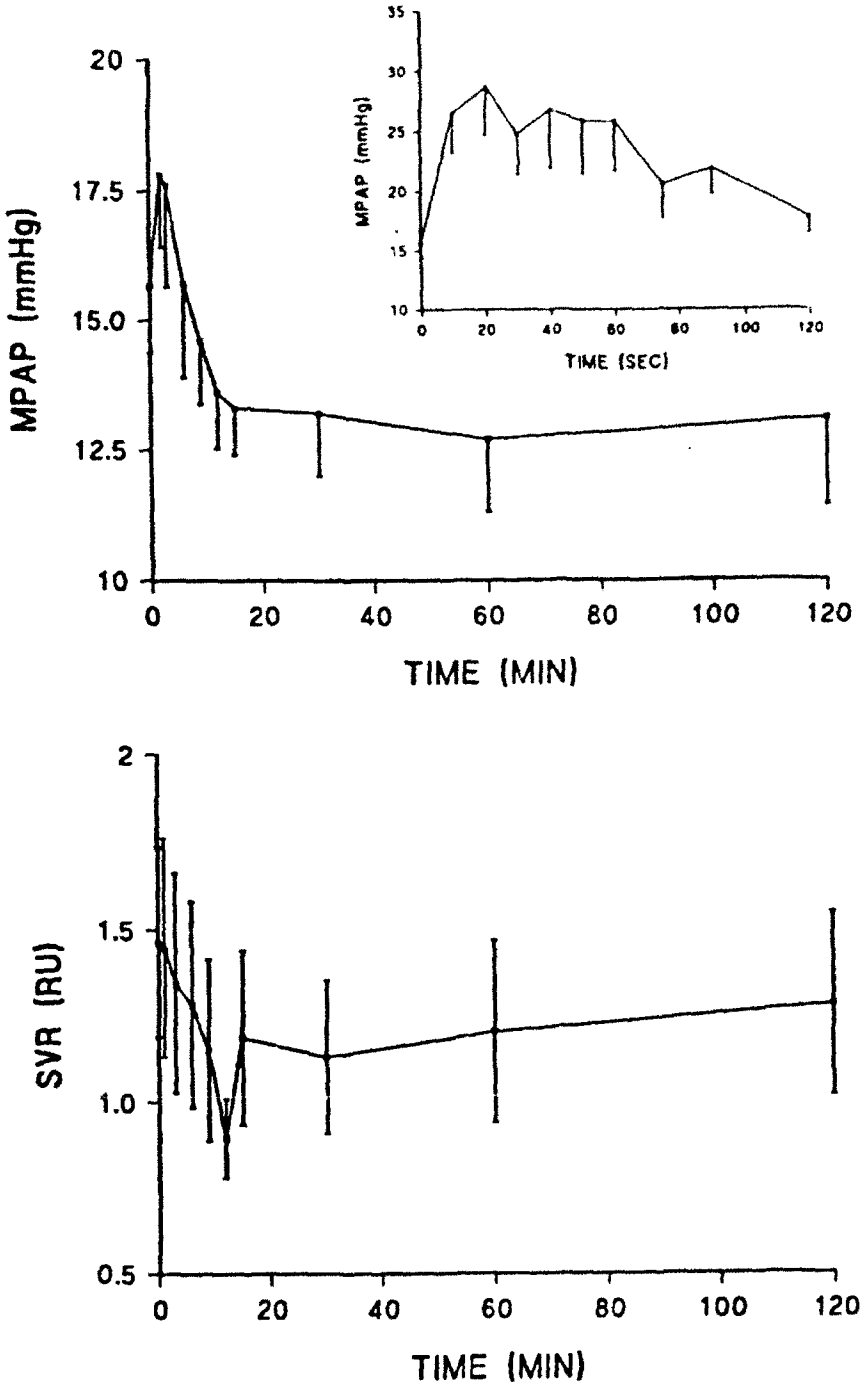


Fig 3 A) Mean pulmonary arterial pressure (MPAP) and B) Systemic Vascular Resistance (SVR) before and following head trauma. Data expressed as mean $\pm$ S.E. from 10 pigs. Small figure depicts changes in MPAP over first 120 sec following head trauma.

OFFICIAL DISTRIBUTION LIST

Commander
US Army Medical Research
& Development Command
ATTN: SGRD-RMS/Mrs. Madigan
Fort Detrick, MD 21701-5012

Defense Technical Information Center
ATTN: DTIC/DDAB (2 copies)
Cameron Station
Alexandria, VA 22304-6145

Office of Under Secretary of Defense
Research and Engineering
ATTN: R&AT (E&LS), Room 3D129
The Pentagon
Washington, DC 20301-3080

DASG-AAFJML
Army/Air Force Joint Medical Library
Offices of the Surgeons General
5109 Leesburg Pike, Room 670
Falls Church, VA 22041-3258

HQ DA (DASG-ZXA)
WASH DC 20310-2300

Commandant
Academy of Health Sciences
US Army
ATTN: HSHA-CDM
Fort Sam Houston, TX 78234-6100

Uniformed Services University of
Health Sciences
Office of Grants Management
4301 Jones Bridge Road
Bethesda, MD 20814-4799

US Army Research Office
ATTN: Chemical and Biological
Sciences Division
PO Box 12211
Research Triangle Park, NC 27709-2211

Director
ATTN: SGRD-UWZ-L
Walter Reed Army Institute of Research
Washington, DC 20307-5100

Commander
US Army Medical Research Institute
of Infectious Diseases
ATTN: SGRD-ULZ-A
Fort Detrick, MD 21701-5011

Commander
US Army Medical Bioengineering Research
and Development Laboratory
ATTN: SGRD-UBG-M
Fort Detrick, Bldg 568
Frederick, MD 21701-5010

Commander
US Army Medical Bioengineering
Research & Development Laboratory
ATTN: Library
Fort Detrick, Bldg 568
Frederick, MD 21701-5010

Commander
US Army Research Institute
of Environmental Medicine
ATTN: SGRD-UE-RSA
Kansas Street
Natick, MA 01760-5007

Commander
US Army Research Institute of
Surgical Research
Fort Sam Houston, TX 78234-6200

Commander
US Army Research Institute of
Chemical Defense
ATTN: SGRD-UV-AJ
Aberdeen Proving Ground, MD 21010-5425

Commander
US Army Aeromedical Research
Laboratory
Fort Rucker, AL 36362-5000

AIR FORCE Office of Scientific
Research (NL)
Building 410, Room A217
Bolling Air Force Base, DC 20332-6448

USAF School of Aerospace Medicine
Document Section
USAFSAM/TSKD
Brooks Air Force Base, TX 78235-5301

Head, Biological Sciences Division
OFFICE OF NAVAL RESEARCH
800 North Quincy Street
Arlington, VA 22217-5000

Commander
Naval Medical Command-02
Department of the Navy
Washington, DC 20372-5120